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Total factor productivity measures for Telstra

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Abstract

Using the Divisia indexation procedure to construct output and input indices for Telstra, this study estimated total factor productivity (TFP) growth rates for the period, 1980–1997. The study reveals that Telstra's TFP growth rates were significantly higher in the post-reform period compared to the pre-reform period. The study further reveals that the terms of trade for Telstra, defined as the ratio of output prices received and input prices paid by Telstra, has declined more sharply in recent years. This reflects Telstra's endeavour, under the competitive pressure, to share productivity gains with consumers. © 2000 Elsevier Science Ltd. All rights reserved.

Keywords: Telstra; Total Factor Productivity (TFP); Australia

1. Introduction

Estimates of total factor productivity measure (TFP) for a firm involves construction of an aggregate output index and an aggregate input index. The ratio of the two indices provides the TFP measure that includes the impact of technical progress, economies of scale or of scope and managerial improvements. Although there are ways of decomposing the estimated TFP, an aggregate measure will be sufficient for our purpose. The purpose of the present study is to provide insight into the sharing of efficiency gains between Telstra and its customers.

The present study is an update of the BIE (1995) using more recent data sourced from Telstra and ABS. The methodology used in constructing the input and output indices is basically the same as BIE (1995) and is described briefly in Section 2 of this paper. Section 3 provides estimates of TFP measures for Telstra and Section 4 provides a summary and conclusions of the paper.

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2. The methodology

A full description of the methodology is provided in Appendix A

2.1. Output

In estimating Telstra's output index, BIE (1995) first divided telecommunications services into seven main activities including the number of telephone calls, total number of telephones rented, new services connected, total number of telex services in operation, total number of telex calls, international calls and other services. These services were then aggregated into an index using the Divisia procedure.¹

Classification of products and the details of reporting have changed since 1994. As a result, the BIE estimates cannot be updated using the same data formats. Some old products such as telex calls and connections have almost disappeared from the market, while some new products like fax lines, ISDN and mobiles have become prominent in the recent past.

Table 1 shows that there has been a significant structural change in demand for Telstra's services in recent times. In 1994, voice services represented more than 56 percent and data and other services about 44 percent of Telstra's revenue. In 1997, contribution of voice services declined to 53 percent and that of data and other services grew to 47 percent.

Within the voice services, local calls remained stable at 32 percent while international calls declined from 19 to 16 percent, trunk calls from 34 percent to only 29 percent over the three years period ending with 1997.

The decline in revenue shares, as described above, reflects average decline in prices while quantity of services continued to increase. Between 1995 and 1997, the number of local calls, trunk calls and international calls have increased by 10.7, 4.5 and 9.4 percent, respectively, while that of mobile calls increased by 63 percent (see Table 2). Revenue shares of mobiles increased from 15.5 to 23.5 percent between 1994 and 1997 (see Table 1).

Table 1
Revenue shares for various Telstra services, 1994–1997^a

Period	Total services (%)			Voice services (%)			
	Calls	Data	Other	Local	Trunk	International	Mobile
1994	56.1	13.0	30.9	31.6	33.6	19.3	15.5
1995	55.0	9.7	35.3	32.4	34.4	18.2	15.0
1996	53.9	10.3	35.8	32.5	30.5	16.3	20.7
1997	52.8	11.8	35.4	31.6	29.1	15.9	23.5

^aSource: BIE (1995), Telstra Annual Reports and ABS.

¹ For details of the indexation procedure, see Diewert (1993).

Table 2
Growth in telephone calls Telstra: 1995–1998^a

Year	Local	Trunk	International	Mobile
1995	9796	9874	1330	1479
1996	10650	10080	1389	2121
1997	10844	10326	1455	2415
Growth rates	10.7	4.6	9.4	63.3

^aSource: Telstra Annual Reports, 1995–1997.

Local calls are in million calls and others in million minutes.

Table 3
Growth rates and price changes: Telstra, 1980–1997^a

Period	Annual growth rates		Changes in real prices	
	Calls	Total output	Calls	Total output
1980–1990	7.2	8.6	– 2.4	– 1.7
1990–1994	4.8	8.8	– 4.9	– 4.8
1994–1997	4.0	10.8	– 9.1	– 9.0
1980–1997	6.0	9.0	– 4.2	– 3.8

^aSource: BIE (1995), Telstra Annual Reports and ABS.

An analysis of market share changes for telecommunications service providers is presented in Appendix B Tables 8 and 9 show that Telstra's market shares in all sectors have declined significantly. This was clearly the outcome of competition introduced in the market since early 1990's. However, despite the decline in the market share for the incumbent Telstra, the overall market size was expanding.

Table 3 shows that the growth rates in the traditional voice services were rather moderate compared to the aggregate output growth. This implies that new products grew faster than the traditional products. The average annual growth rate for the period, 1995–1997, was approximately 4 percent per annum, while the corresponding growth rate for Telstra's aggregate output was 10.8 percent over the same period.

The large growth in Telstra's output coincided with the significant decline in its prices. As can be seen from Table 3, Telstra's call prices in real terms have declined at the rate of 4.2 percent per annum since 1980 while its aggregate price declined by 3.8 percent per annum over the same period. The largest growth in Telstra's aggregate output and largest fall in its prices were coincided with the introduction of competition in the Australian market since 1992.

Following BIE (1995), the present study used the Divisia procedure to make an output index. Because of the significant structural changes in demand in recent times and the

introduction/disappearance of a number of products, aggregate output was calculated from the respective revenues at constant prices rather than the actual quantity of services as in the BIE (1995). Moreover, in order to preserve the historical product shares, the present study used the price variables in index forms, while the BIE used them in dollar terms. This difference in the procedure, however, did not significantly change the BIE estimate of growth rates derived from the actual quantity changes.

Thus, although the basket of products was different for the more recent period, the quantity index constructed using the revenue at constant prices provides a meaningful comparison of output growth rates for Telstra over time.

2.2. Input

As in the case of output index, the present study followed BIE (1995) in estimating the input index. Cost components have been classified under three broad classification: labour, capital and other costs. Other costs have been calculated as total costs (as reported by Telstra) less labour and capital costs. The price of labour (wages) has been calculated as the ratio of Telstra's labour cost to full time equivalent of labour employed by Telstra. The dollar value of wage rates was then converted into an index and used to deflate the labour cost. The deflated labour cost was used as labour input. This was considered necessary to maintain consistency in the treatment of all inputs. The other costs have been deflated by the implicit price deflator for equipment used in telecommunications industry.

Capital cost is the most difficult input cost to estimate. The methodology used for the present purpose is the same as BIE (1995). The major points are, however, described below.

2.2.1. Estimating capital and capital costs

The important question for TFP calculations is whether more or less capital is required to produce the same quantity of output. The capital input is the annualised value of capital services. This annualised value is an outcome of a combination of factors such as the stock of capital, the price of capital and the depreciation method used. For example, declining balance depreciation will reduce capital input in subsequent years for the same level of output. This will increase the TFP growth rates without real improvement in efficiency. A straight line depreciation method is free from this problem.

In the present paper, depreciation costs are calculated on the current value of assets to make it comparable with other costs which are in current prices. However, the capital stock is deflated by an asset price index (ABS) to represent capital input in real terms.

Following Industry Commission (1990) the annualised user cost of capital was estimated as

$$\text{VAUC}_t = (r_t + d - \Delta P_t/P_{t-1})P_t K_t, \quad (1)$$

where r is the opportunity cost of holding capital representing the 10 year bond rate in year t ; d is the declining balance depreciation rate (assuming an average asset life of 12 years; $\Delta P_t/P_{t-1}$ is the annual rate of change in the price of capital; P_t is the price of capital; and K_t is the physical quantity of capital stock in year t .

The value of physical quantity of capital stock was estimated using the perpetual inventory method (PIM) with Telstra's value of assets in 1980 as the starting point.²

$$PK_t = [(1 - d)PK_{t-1}](1 + \Delta P) + INVT_t - DISP, \quad (2)$$

where PK_t is the value of assets at current prices in year t ; ΔP is the change in the ABS capital price index, i.e. $[(P_t/P_{t-1}) - 1]$; $INVT_t$ is the investment on assets in year t ; and $DISP$ is the value of asset disposals.

In estimating Eqs. (1) and (2), we have used the implied declining balance depreciation rate, d . This is defined in Eq. (3) and was first used by Industry Commission (1990). This rate equates the present value of a declining balance depreciation charge to the present value of an ' L ' year straight line depreciation charge reflecting zero residual value, for alternative subjective discount rates:

$$DD = rX(L - X), \quad (3)$$

where $X = ((1 - r)^L - 1)/(r(1 + r)^L)$; DD is the declining balance depreciation; r is the discount/interest rate; and L is the asset life.

3. Estimates of total factor productivity

As stated earlier, input and output indices for Telstra have been constructed using data sourced from BIE (1995), Telstra annual reports and ABS. The estimated growth rates in total productivity are provided in Tables 4 and 5.

The table shows that the annual compound growth rate for the period, 1980–1997, is estimated to be 6.5 percent while those for the periods, 1980–1991 and 1992–1997 are 4.9 and 10.1 percent, respectively. A substantially high growth rate of 18 percent was achieved in 1993, just after introduction of partial competition in 1991–1992. The growth rate had come down to 3.6 percent in 1996 and picked up again in 1997 to 10 percent.

The estimated results are in sharp contrast with the trend provided by BIE (1995). Apparently, they also look inconsistent with Telstra's declining market share as competitors attract former Telstra customers. However, this effect appears to have been small relative to the effect of competition in reducing prices and increasing service quality and, thereby, expanding Telstra's sale. Moreover, with the introduction of new technology and new products, the size of the market itself has also expanded significantly.

A further impetus to the TFP growth rates was provided by significant downsizing of Telstra since 1991. In 1992 alone, more than 13 000 full time equivalent staff were retrenched. This was about 16 percent of its work force. The downsizing continued throughout the study period. In 1998, Telstra's work force was about 14 000 less than it was in 1992. The downsizing followed the regulatory reforms introduced in Telecommunications Act 1991 that removed the official barriers to entry into the Australian telecommunications market.

² A detailed discussion on the PIM method is available in Industry Commission (1990). The method was pioneered by Garland and Goldsmith (1959) and subsequently developed by Christensen and Jorgenson (1969).

Table 4

Output input and TFP indexes: Telstra (1980–1997)^a

Years	Output index	Input index	TFP	Growth rates (TFP)
1980	1.00	1.00	1.00	—
1981	1.11	1.00	1.11	10.9
1982	1.17	1.02	1.15	3.9
1983	1.23	1.05	1.17	1.5
1984	1.33	1.11	1.20	2.3
1985	1.43	1.19	1.21	0.9
1986	1.58	1.17	1.35	11.8
1987	1.70	1.22	1.39	3.4
1988	1.94	1.30	1.49	6.5
1989	2.03	1.30	1.57	5.6
1990	2.28	1.42	1.61	2.3
1991	2.42	1.43	1.70	5.6
1992	2.72	1.52	1.79	5.6
1993	2.93	1.38	2.12	18.2
1994	3.20	1.35	2.36	11.5
1995	3.49	1.37	2.55	7.9
1996	3.81	1.44	2.64	3.6
1997	4.35	1.50	2.90	9.8

^aSource: BIE (1995), ACCC (1998).

Table 5

Compound annual growth rate for Telstra's TFP^a

Period	Annual growth rate
1980–1997	6.5%
1980–1991	4.9%
1992–1997	10.1%

^aSource: Telstra's data, ACCC estimates.

3.1. Distribution of productivity gains

Productivity measures are important because they help in the determination of how the gains will be distributed among various productive agents and consumers. A corollary of productivity measure is terms of trade (TOT) estimate. The TOT is defined as the ratio of output prices received and input prices paid by Telstra. The estimated TOT is presented in Fig. 1.

It can be seen from Fig. 1 that the terms of trade for Telstra has continuously declined since 1981. The decline was more pronounced in recent years. This reflects Telstra's endeavour to keep the increase in output prices lower than the increase in input prices and to share productivity gains

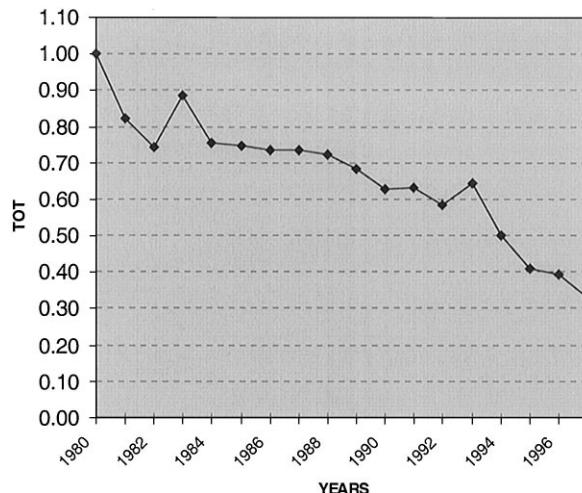


Fig. 1. The ratio of output to input price indices.

Table 6
Terms of trade for Telstra

Year	Output price	Input price	Terms of trade
1980	1.000	1.00	1.00
1981	1.030	1.25	0.82
1982	1.160	1.56	0.74
1983	1.310	1.48	0.89
1984	1.400	1.86	0.75
1985	1.470	1.97	0.75
1986	1.530	2.08	0.74
1987	1.580	2.15	0.73
1988	1.750	2.42	0.72
1989	1.850	2.71	0.68
1990	1.850	2.95	0.63
1991	1.880	2.98	0.63
1992	1.820	3.11	0.59
1993	1.760	2.74	0.64
1994	1.700	3.41	0.50
1995	1.640	4.02	0.41
1996	1.540	3.93	0.39
1997	1.390	4.22	0.33
Gr rate (1981–1997)	1.95	8.84	(6.3)
Gr rate (1992–1997)	(4.90)	5.97	(10.2)

with consumers. Table 6 shows that, between 1992 and 1997, Telstra's aggregate output price has continuously declined at an annual rate of 4.9 percent despite a sharp input price increase at about 6 percent per annum.

4. Summary and Conclusions

This study reported Telstra's productivity growth for the period, 1980–1997. The study reveals that the TFP growth rates for Telstra were significantly higher in the post-reform period compared to the pre-reform period. The estimated growth rates for the period, 1980–1991, were 4.9 percent per annum, while those for the period, 1992–1997 were 10.1 percent. A substantially high growth rate of 18 percent was achieved in 1993, just after introduction of partial competition in 1991–1992.

The study further reveals that the terms of trade for Telstra, defined as the ratio of output prices received and input prices paid by Telstra, has declined more sharply in recent years. This reflects Telstra's endeavour, under the competitive pressure, to share productivity gains with consumers. Between 1992 and 1997, Telstra's aggregate output price has declined at an annual rate of 4.9 percent despite a sharp input price increase at about 6 percent per annum.

The study finds that although Telstra's market share has declined as competitors attracted former Telstra customers, its sales continued to increase due to reduced prices and improved service quality. The study also concludes that, with the introduction of new technology and new products, the size of the market itself also expanded significantly. The downsizing of Telstra's workforce also provided impetus to the TFP growth rates.

The results presented in this paper need to be treated cautiously. Higher growth rates and inefficiency may co-exist in enterprises substantially below the best practice levels. Levels of productivity gains need to be compared along with productivity growth rates. For international comparisons, data for other countries need to be incorporated to estimate productivity levels and growth rates across countries.

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Appendix A. Measuring total factor productivity

The rate of growth of TFP (ΔTFP) is given by (For further details, see Rushdi (1994, pp. 42–43)).

$$\Delta\text{TFP} = \Delta\log Q - \Delta\log X, \quad (\text{A.1})$$

where Q is the aggregate output and X the aggregate input.

The growth rate of aggregate output ($\Delta\log Q$) is given by Eq. (A.2), where aggregate output is calculated by weighting the revenueshares of individual outputs (V_{it}), using Eq. (A.4). The aggregate output index is given by Eq. (3):

$$\Delta\log Q = \log(Q_t/Q_{t-1}) = \sum_{i=1}^n V_{it} \log(q_{it}/q_{it-1}). \quad (\text{A.2})$$

Rearranging Eq. (A.2):

$$Q_t = Q_{t-1} \text{ antilog}\left\{\left(\sum_{j=1}^n V_{it} \log(q_{it}/q_{it-1})\right)\right\}, \quad (\text{A.3})$$

where

$$V_{it} = \{(p_{it} q_{it} / \sum_{j=1}^n p_{jt} q_{jt}) + (p_{it-1} q_{it-1} / \sum_{j=1}^n p_{jt-1} q_{jt-1})\}/2, \quad (\text{A.4})$$

p_{it} is the price of item i at time t , q_{it} is the quantity of item i at time t , and Q_t is the aggregate output at time t .

We may note that V_{it} is averaged over year t and $t-1$. Eq. (A.2) can also be used to calculate the growth rate of aggregate input ($\Delta \log X$) by replacing Q with X , and q_s with x_s . Eq. (A.3) can also be used to derive the aggregate input index, where Q is replaced by X , and q_{it} is replaced by x_{it} .

Appendix B. Market share changes for telecommunications service providers in Australia (1994–1997)

Market shares for the four major telecommunications service providers in Australia is presented in Table 7. The market shares have been defined as the ratio of net revenue of a firm to the sum of net revenue of all participating firms in the industry. The net revenue was calculated by deducting transfer pricing revenue and non-telecommunications revenue from the gross revenue of a firm.

Table 7 shows that Telstra's market share has declined from 94 percent in 1994 to 85 percent in 1997 while that of Optus has increased from 6 percent to about 13 percent over the same period. Vodafone and AAPT represented about 2 percent in 1997. The table also shows that, despite Telstra having the lowest growth during the period (6.1 percent per annum), its increase in revenue in dollar terms was significantly larger than that of Optus (i.e. \$2620 as against \$1718 for Optus).

A breakdown of the aggregate revenue growth rates is provided in Table 2. It shows that Telstra's market share has significantly declined in areas where it faces competition. For example, in mobile telecommunications, Telstra's share has declined from 81 percent in 1994 to 62 percent in 1997 while that of Optus has increased from 18 to 30 percent over the same period. Vodafone has increased its share from less than 1 percent in 1994 to about 8 percent in 1997. Optus share in international calls, almost doubled in three years to 1997 while that of Telstra has declined from 85 to 71 percent over the same period. In the trunk calls market, Telstra's revenue has declined from 93 to 81 percent while Optus share increased from 5 to 15 percent in three years to 1997. By contrast, Telstra's share in local call market has remained, by and large, stable at almost 100 percent reflecting the absence of competition in this market (Tables 8 and 9).

Table 7

Telstra call price ^a									
Year	CALLP	CPI	Real callp	Aggr P (current)	CPI 1980	Real AGGR P	Index RCALL P		
1980	0.25	45.2	0.56	1.00	1.00	1.00	1.00		
1981	0.26	49.4	0.52	1.03	1.09	0.94	0.93		
1982	0.28	54.6	0.52	1.16	1.21	0.96	0.93		
1983	0.31	60.9	0.51	1.31	1.35	0.97	0.92		
1984	0.33	65.0	0.50	1.40	1.44	0.97	0.90		
1985	0.35	67.8	0.51	1.47	1.50	0.98	0.92		
1986	0.36	73.5	0.49	1.53	1.63	0.94	0.89		
1987	0.37	80.4	0.46	1.58	1.78	0.89	0.82		
1988	0.40	86.3	0.47	1.75	1.91	0.92	0.84		
1989	0.43	92.6	0.47	1.85	2.05	0.90	0.84		
1990	0.44	100.0	0.44	1.85	2.21	0.84	0.78		
1991	0.44	105.3	0.42	1.88	2.33	0.81	0.75		
1992	0.43	107.3	0.40	1.82	2.37	0.77	0.72		
1993	0.41	108.4	0.38	1.76	2.40	0.73	0.68		
1994	0.40	110.4	0.36	1.70	2.44	0.69	0.65		
1995	0.38	113.9	0.34	1.64	2.52	0.65	0.60		
1996	0.36	118.7	0.30	1.54	2.63	0.59	0.54		
1997	0.32	120.3	0.27	1.39	2.66	0.52	0.48		
Shares and growth rates									
years	LCalls	\$m	TCalls	\$m	ICalls	\$m	Mobile	\$m	TR
1994		2650		3050		1400			7100
1995	9796	2508	9874	2665	1330	1412	1479	1166	7751
1996	10 650	2669	10 080	2505	1389	1338	2121	1705	8217
1997	10 844	2664	10 326	2455	1455	1342	2415	1981	8442
1998	11 138	2664	11 319	2594	1472	1380	2720	2154	
GR	1.107		1.046		1.094		1.633		
Shares	LCalls		TCalls		ICalls		Mobile		
1994	0.37		0.43		0.20		0.00		
1995	0.32		0.34		0.18		0.015		
1996	0.32		0.30		0.16		0.21		
1997	0.32		0.29		0.16		0.23		

^aSource: BIE (1995), Telstra Annual Reports

Table 8
Revenue shares: Australian Telecom Industry (\$m)^a

Years	Telstra		Optus		Vodafone		AAPT		Total	
	\$m	%	\$m	%	\$m	%	\$m	%	\$m	%
1994	13 363	94.0	836	5.9	3.9	0.0	86.8	0.1	14290	100
1995	14 081	90.0	1450	9.0	69	0.0	132.4	1.0	15732	100
1996	15 239	87.8	1954	11.0	171	1.0	167.8	1.0	17532	100
1997	15 983	85.0	2554	13.0	242	1.0	197.4	1.0	18976	100
GR	6.1		45.1		295.9		31.5		9.9%	

^aSource: Telstra Annual Reports and Austel.

GR is annual growth rate.

Table 9
Market shares by sub-markets^a

Local calls	Telstra	Optus	Vodafone	AAPT	Total
1994	100.0	0.0	—	—	100
1995	99.5	0.5	—	—	100
1996	99.3	0.7	—	—	100
1997	98.7	1.3	—	—	100
Mobiles	Telstra	Optus	Vodafone	AAPT	Total
1994	81.4	18.4	0.3	—	100
1995	68.0	28.0	4.0	—	100
1996	66.3	27.1	6.6	—	100
1997	62.2	30.2	7.6	—	100
Int'lernational	Telstra	Optus	Vodafone	AAPT	Total
1994	85.0	14.0	—	1.0	100
1995	78.0	20.0	—	2.0	100
1996	73.0	24.0	—	3.0	100
1997	71.0	26.0	—	3.0	100
Trunk Calls	Telstra	Optus	Vodafone	AAPT	Total
1994	93.2	5.0	—	1.8	100
1995	88.1	9.2	—	2.7	100
1996	84.2	12.6	—	3.2	100
1997	81.2	15.4	—	3.4	100

^aSource: Telstra Annual Reports and Austel.

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